SAB GUIDANCE AND CONTROL PANEL

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(U) REPORT OF THE SCIENTIFIC ADVISORY BOARD GUIDANCE & CONTROL PANEL ON SATELLITE INTERCEPTION

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1. INTRODUCTION

The Guidance and Control Panel has made a fairly thorough review over the past six months of the Air Force Space Program. Particular emphasis has been focused on satellite interceptor ideas because this part of the space program is in an advanced formulative stage and guidance and control problems associated with its development are typical and broad in scope. This report reflects the views of the Panel on the satellite interceptor and therefore represents only an initial look at Guidance and Control aspects of the entire space program.

2. CONCLUSIONS

Problems of identification, classification and orbital prediction of target satellites from ground sources are not being treated in a manner consistent with the requirements of the satellite interceptor program.

Processes to be used in the inspection of target satellites are of primary importance and attention to these problems must be a matter of first priority.

The state of technology in guidance, stabilization, propulsion and terminal guidance for rendezvous is sufficiently advanced to accomplish the results desired in an experimental program. However, particular attention should be given to the problems of energy management associated with orbital changing and rendezvous.

Our evaluation indicates that the Air Force is uniquely qualified to conduct the program.

We concur with the Air Force position regarding the potential military value of an inspector killer satellite interceptor weapon system.

3. RECOMMENDATIONS

That the Air Force proceed now with an experimental program aimed at the early demonstration of the interrelated techniques needed for an inspector satellite system. Techniques should include precision insertion guidance, orbital changes, rendezvous, station-keeping, and inspection processes.

That the Air Force proceed with a research and development program for the development of inertial components incorporating small size, light weight, low power consumption, and long and reliable life.

4. DISCUSSION

In view of the significant progress being achieved both in the U.S.A. and the U.S.S.R., it is likely that a real threat faces this country in the form of Soviet military satellites for reconnaissance, communications, early warning, anti-ICBM, and possibly bombardment. A counter-weapon must be developed. However, the type of weapon to be developed depends in large measure on the nature of expected international relations and certain elements of "space" law. If we were preparing only for a hot war situation, a suitable weapon might be much like the concept previously referred to as "Silver Saint", a ballistic weapon fired co-planar with the orbit of the enemy satellite. This proposed project known also as "Tactical Killer" represents an approach based upon deciding on the ground that a particular unknown satellite is hostile. The act of killing the satellite would supposedly follow. Such an act in a cold war situation may be regarded as hostile or aggressive and some alternative seems in order.

The alternative is a more complex device called an "inspector/killer interceptor" satellite. This device, called Saint, is conceived as one which would become co-orbital and essentially co-positional with the enemy satellite, then using certain inspection and communication techniques to inform a ground control post of desired characteristics.

Based upon such information and other intelligence, a decision might be made to take neutralizing action. The ability to neutralize upon command would exist in the interceptor. Such an interceptor may be either ground or air-launched and it may be manned or unmanned. Obviously, early models would be unmanned and preliminary studies show ground launch to be most desirable.

It is understood at this time that the Air Force has recommended to DDR&E through ARPA, the pursuit of the inspector satellite approach. The Panel indorses this recommendation and suggests that the project include a research and experimental objective aimed at the effective and sequential gathering of engineering design information and the evolution of techniques necessary for the ultimate construction of a military operational weapon system. This design information can be formulated through the conduct of system demonstration tests and the investigation of certain critical problems such as:

a. The degree of precision (and probability) in establishing orbits of desired characteristics.

b. The limitations (if any) of ground tracking, station keeping, and cataloging systems.

c. Methods of secure communication and command-control of the interceptor.

d. Terminal guidance and rendezvous techniques just prior to inspection and/or kill.

e. The inspection process itself.

All the above technology is essential to the inspection satellite and in fact Item e is fundamental to the concept even though somewhat outside the direct scope of the Guidance and Control Panel.

It is also noted that solution of any of these will contribute directly to the over-all "state of the art" required to advance a variety of Air Force and National Space Missions. Examples of other applications of this technology are:

a. Rendezvous with our own satellites for refueling, damage assessment maintenance, and eventually for transfer of personnel.

b. Development of techniques for attaining precision orbits and orbital changes. This technology will be directly applicable to communication, reconnaissance, early warning and bombardment satellites.

c. Clarification of requirements for station-keeping and consolidated cataloguing systems.

d. Development of techniques which will be essential to the implementation of any international space control schemes.

e. Clarification of requirements for a manned satellite system to assist in the rendezvous and/or inspection processes.

The initial experimental program should include demonstration tests in order to gain experience and data for the design of a satellite interceptor and in order to provide a test bed for satellite research items such as the inspection sensors. This test program should be initiated promptly and might be organized in two phases so that the results can be achieved at the earliest possible time. The first phase would include transfer from one orbit to another at a specified time and would not require actual satellite targets. The second phase would provide the opportunity to test the rendezvous operation utilizing the orbiting vehicles from the first phase as targets. It is important that the ground environment and particularly the telemetering, communications and data reduction aspects of this effort be developed concurrently with the experimental program.

More explicitly, the first phase will require a suitable booster and terminal vehicle combination utilizing facilities that are available at Cape Canaveral and AMR. The terminal vehicle would be inserted into a prescribed orbit at a prescribed time by use of inertial guidance equipment contained in the terminal vehicle. The orbital information would be introduced into the guidance computer prior to launch.

Radar and computer equipment required for the Pacific and Atlantic ranges as well as Space Track will provide actual orbital data to be compared with the desired orbital parameters. The ground environment will also be used to compute and command transfer into coincidence with a simulated target. This transfer will involve ground-to-satellite communication equipment and programming equipment within the satellite. The satellite will also contain telemetering and data storage so that guidance and propulsion control performance data obtained during the transfer maneuver can be compared with orbital measurements

derived on the ground. Consideration should be given to the installation of TV sensors in these vehicles to provide information when these vehicles serve as targets for the second phase.

The second phase will necessitate use of all the equipment required in the first phase in addition to high speed computation for missile launch and a terminal seeker for target rendezvous. A ground radar will track the target just prior to launch. A high speed computer will employ the radar tracking data to determining the target orbit, the inertial guidance settings, and the time for launch. The inertial guidance will control during the boost, orbital injection and orbital change phases until such time as the seeker locks on target. The terminal vehicle will then be brought in close proximity to the target and will be kept on station by stabilization jets. TV pictures will be transmitted to the ground along with detailed guidance and control information. These results will be compared as in Phase I with the ground derived data.

Guidance and Control

a. Inertial Guidance

The satellite interceptor program will require an inertial platform to provide both guidance and control information for the initial insertion into orbit, orbit changing and during the rendezvous and station keeping phases.

For the demonstration tests, inertial components capable of meeting requirements similar to those established for the Titan and Minuteman programs should be satisfactory. Units of this type are in production and should be available.

Although components similar to the above have shown high performance and reasonably long life, sufficient evidence is not available to prove their capability of satisfying the requirements for a one year life in orbit as may be required by an operational system.

Consideration should be given to the use of a star tracker as an aid in meeting the accuracy performance requirements. Improved reliability may be expected as the result of continued product engineering during the production phase of other programs.

For the operational satellite interceptor, it is important to have reduced size, weight, power consumption, and increased reliability and life. Therefore, it is important that development in these areas be started now.

While the inertial components above appear satisfactory for the job, continued development is essential for reduced size, weight, power consumption and increased life.

b. Rendezvous

To achieve rendezvous, it is necessary to detect and track the target from the satellite interceptor, as well as to control the thrust vector to maneuver close to the target. Sufficient range and angle coverage must be provided to absorb all the expected positional errors from the orbital guidance equipment and the ground surveillance system. Also, this sensor should be capable of keeping continuous surveillance of the target, even at close range, so that station-keeping signals can be obtained to operate the variable-control gas jets.

The basic sensors for establishing a horizontal reference plane on the vehicle can be either of the horizon scanning type or the gravity gradient type. While detailed system studies must be made to establish performance requirements, theoretical studies show that these devices can provide a reference plane to within 0.1°.

Actuators can be of the gas jet type for coarse control in order to reduce orbital injection errors to tolerable levels and reaction wheels can be used to maintain vernier control during the operational lifetime of the satellite.

The major military purpose of an operational satellite inspector system must be that of thorough inspection of all such enemy systems. The ability to perform inspection satisfactorily represents the major technical objective of the proposed program and care must be taken to insure that basic and applied research and development required in this key area begin concurrently with Phase I.

The USSR could place into orbit a satellite with a surveillance and/or offensive capability but characterized by a very small radar cross section and hence, relatively difficult to inspect except at close range.

Methods of inspection can include portions of the whole electromagnetic spectrum-and it is obviously necessary to determine the significant physical characteristics of the unknown satellite, i.e., size, shape, volume and weight. It is also important to ascertain the ability of the enemy vehicle to radiate and/or receive electromagnetic signals and, if possible, the ability of the vehicle to subdivide either weightwise or volumewise.

A method of inspection may utilize radar to measure changes in the velocity caused by a beam of small particles ejected by the inspector into the path of the unknown. Then by knowledge of the other factors governing the motion of the satellite, it may be possible to determine its mass.

Given identification, possible means of destruction or neutralization are as follows:

a. "Conventional" warheads (fragments, shaped charges, etc.) producing small holes.

b. Nuclear warheads.

c. Paint (Blind, destroy temperature balance, incapacitate solar cells, etc.).

d. Blanket (Wrap in flexible cover for same purposes as c above.)

e. Out talk (Affix jammer)

f. Leech (Attach warhead and radio relay with ground controlled fuze).

g. Disorbit by attaching retro-rocket.

With the exception of the nuclear warhead, all of the above methods require closure to almost zero range.

Neutralization may be preferred to destruction and may be accomplished with or without physical contact with the enemy satellite, and may involve either continuous or intermittent neutralization. In the latter case, interference, might be provided only when the satellite is over the U.S. or other friendly territory. It is desirable to give

the interceptor satellite the capability of destroying the target on command from the ground or automatically upon unusual action of the target as outlined above.

Recovery of the experimental satellites should probably be avoided during the early phases of experimentation. Recovery is a well recognized need which may be pursued as a separate program but should not be allowed to complicate this one. Therefore, provisions for telemetering of all pertinent data should be made.

Since the purpose of this program is to demonstrate rendezvous and inspection techniques against target satellites at an early date, considerable emphasis should be placed on obtaining good reliability of vehicular experimental electronic hardware in a short period. Although much progress is being made in the field of miniaturization, using micro-size and molecularly engineered components, the interceptor demonstrations phase should definitely use electronic concepts which are proven and simple. The size and weight allocations for this equipment should not be so restrictive as to force the designer to use any techniques which are not thoroughly proven.